

THE CAUSE *of*
HOOKWORM DISEASE
its
PREVENTION *and* CURE

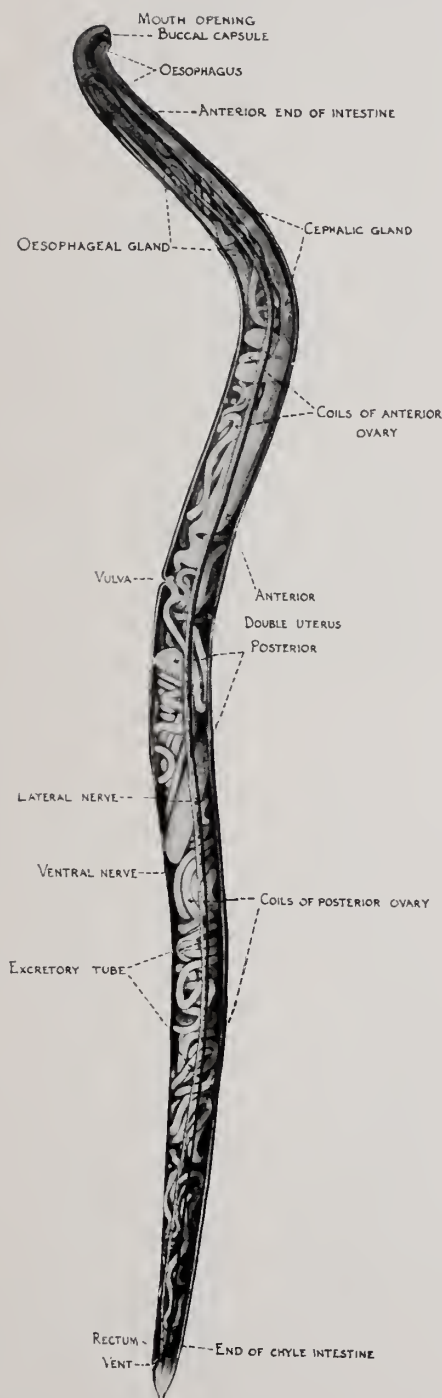
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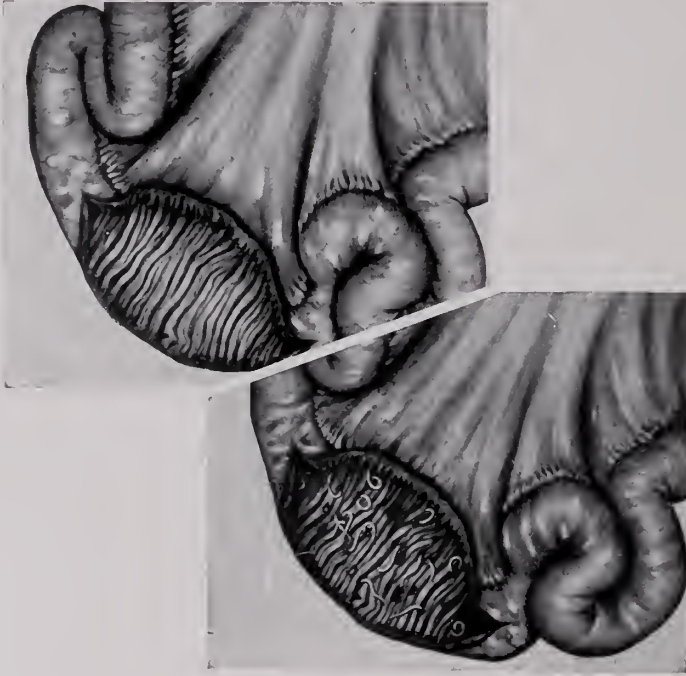
Female Hookworm—magnified 10 to 12 times.

HOOKWORM disease occurs in tropical and sub-tropical countries, also in warm underground workings or mines in colder climates. Under these latter conditions Hookworm disease is met with in California, Wales, Cornwall, Holland, Belgium, Spain and Germany. The disease is due to the presence of hookworms in the intestinal tract from which they derive their nourishment.

The two species of hookworm most commonly infesting man are the Old-world type (*Anchylostoma duodenale*) and the New-world type (*Necator americanus*). The last mentioned species is slightly smaller than the former and is more commonly met with in this country. The two species resemble each other in their general appearance, life histories, methods of infecting man, and the serious symptoms they produce. Furthermore, the methods and results of treatment are the same. They differ from each other in the number and arrangement of the teeth and lancets in their mouths, and also in the location and structure of the parts by which the sexes are distinguished.

The adult worms inhabit chiefly the second part of the small intestine (jejunum), but occasionally they are found in other parts of the digestive tract. The adult female is a little over

half an inch in length, about the thickness of a wire hairpin and tapers slightly to both ends. The adult male is a little over one-third of an inch long. The head resembles that of the female, but the tail end, instead of being pointed, expands into an umbrella-shaped sac or bursa which is concerned in copulation.



Section of intestines before and after Hookworm infestation.

The adult worms attach themselves to the inner lining (mucosa) of the intestine, which they suck in and ingest along with the blood. They are voracious feeders and consume more tissue and blood than they can digest. From time to time they shift their location, and thus leave bleeding points to make new ones. The damage done by them in the intestines is responsible for the serious results which give rise to the group of symptoms known as Hookworm disease. The gravity of the disease is in direct relation to the number of worms infesting an individual. The disease is very insidious and the patient is not aware of the cause of his ill-health. A few worms, and even a moderate number, may not interfere seriously with the health of the host, although they act as a handicap to his development, but when several hundreds or thousands of them infest an individual, each one sucking his life blood and leaving wounds subject to bacterial invasion, the extreme gravity of the resulting condition can be thoroughly appreciated. The person infested shows rapidly increasing anæmia through loss of blood. The skin, tongue, lips, palate and inner surface of the eyelids become very pale and in advanced cases apparently bloodless. Digestive disturbances follow, the appetite becomes fickle,



(a) Result of Hookworm infestation.



(b) Condition short time after treatment for Hookworm.

and at times depraved, as shown in the desire to eat clay, chalk and other unnatural foods. The stomach may be dilated and the abdomen protuberant. Physical and mental development in children is retarded. A child of 16 may have the appearance of one 10 to 12 years of age. The victims are mentally backward, apathetic, devoid of energy, tired, easily fatigued, with no desire for muscular exertion or mental activity, and



A severe case of Hookworm disease with typical symptoms.

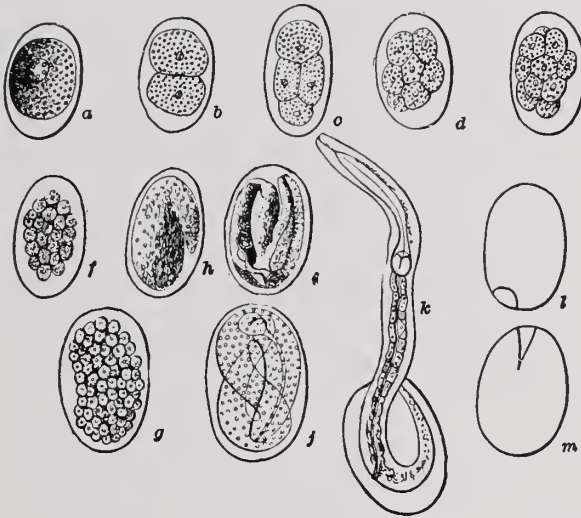
through their lowered resistance subject to the onset of other diseases. In advanced cases the feet, ankles and eyelids swell, general dropsy follows, and death ensues from fatty degeneration of the heart and other viscera.



Effect of Hookworm Disease on Growth. Left, boy of eighteen years, Hookworm free; right, boy of nineteen, heavily infected with Hookworms.

HOW DOES ONE CONTRACT HOOKWORM?

The adult females continually produce over long periods enormous numbers of eggs which become mixed and evacuated with the feces of the host. As many as 4,000,000 eggs may be evacuated daily in cases of severe infestation. A mature female may deposit 9000 eggs daily. These eggs are too small ($1\frac{1}{625} \times 1\frac{1}{350}$ inch) to be seen without the aid of a microscope. An excellent method for the examination of stools for hookworm infection is to take a bit of feces, about as large as a bean, place it in a shallow two-dram tin pillbox, mix it with a super-saturated solution of salt water, fill the box to the top, lay on it the microscopic slides and let it rest for a few minutes. All the eggs in the specimen will float to the



Development of Anchylostoma Duodenale. a-g, changes occurring in egg preparatory to developing of little worm; h-k, stages of the worm's development until it emerges from the egg-shell; l and m, empty egg-shells, greatly enlarged.

top and become attached to the slide, which can be lifted off and examined under the microscope.

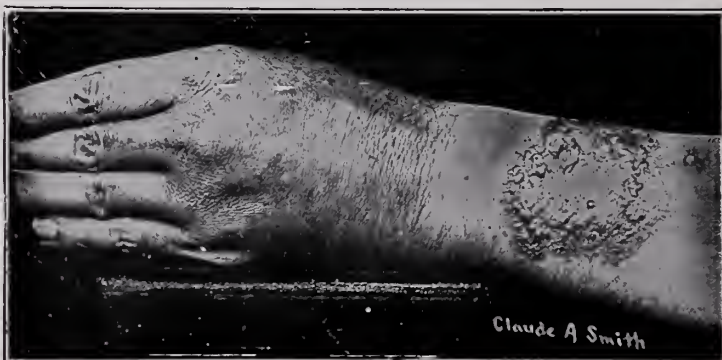
Because of the lack of air in the intestines the eggs are unable to develop there beyond simple division of the yolk into from two to four parts. When, however, the eggs are exposed to the air and conditions are favorable they develop in about two days into young larvæ. At this stage they are about $1/125$ th to $1/100$ th of an inch in length. They grow rapidly and about the third day are $1/80$ th of an inch in length. When development is normal they double their length in from five days to a week, when they cease to feed but remain motile for weeks or months in an infectious stage without further change. Up to and during this stage of their development, shade, moisture and a warm temperature (57° F. to 99° F.) are necessary, and they are readily destroyed by extremes of

temperature, direct sunlight, dryness and the liquid contents of septic tanks. Though motile they never travel to any distance but are conveyed mechanically on the foot gear of the human individuals or on the feet of any domestic animal. Pigs and chickens devouring fresh fecal material



Hookworm Larvæ Piercing the Skin. The photograph shows a portion of skin, greatly magnified.

containing the eggs may scatter them far and wide in their droppings, as some of the eggs pass through their alimentary tracts unchanged. When an opportunity occurs for the larvæ to come in contact with the exposed skin on the foot, leg or arm of some individual, they bore vigor-



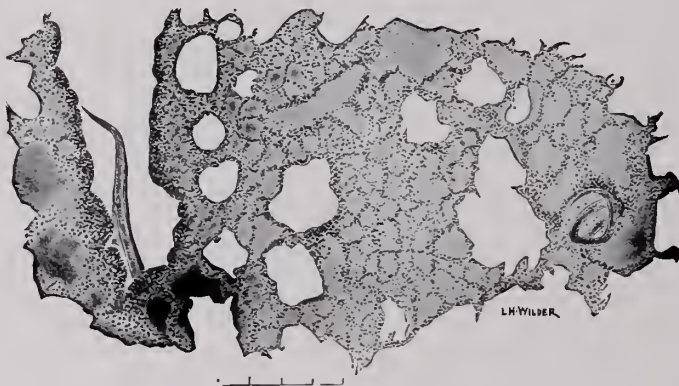
Site of Entrance of Hookworm Larvæ.



Hookworm Larva Penetrating the Skin, Greatly Magnified.

ously into it (generally through the hair follicles), causing intense itching. In the Southern states this irritation is known as "ground itch," "foot itch," or "dew itch." In the Latin countries it is known by the name of "Mazamorra." After boring through the skin they gain entrance to the lymphatic vessels and veins, and in this way are carried in the blood stream to the heart and thence to the lungs. As they are too large to pass through their small blood vessels (capillaries), they bore through their walls and enter the air cells. From these they go directly up through

the bronchial tubes, wind-pipe and larynx to the throat, whence they are swallowed and enter the stomach. They resist the action of its digestive juices and pass on to the small intestine, where they undergo further development, and reach maturity. It takes the larvæ from seven to ten days after they enter the skin to reach the small intestine, at which time they are about one-twelfth of an inch long. About six days afterwards they are an eighth to a fifth of an inch in length. In from two to three weeks thereafter they become mature, when fertilization takes place. From six to eight weeks after the larvæ enter the skin of the host eggs appear in the feces. This method of infection has been determined by careful study. It is possible, however, for the larvæ to pass directly to the intestines without going through the lungs. The young infective larvæ may occasionally be swallowed with uncooked vegetables or fruit that have been soiled, or in drinking polluted water. Uncooked vegetables,



Two Young Hookworms in the Lungs. The worm on the left is entering the air tubes.

from gardens in tropical countries where human feces is used as a fertilizer, should not be eaten.

The length of life of the adult worm in the intestines is unknown. Some claim that it will live for a couple of years; others, for eight to ten years. If, therefore, there is no secondary infection Hookworm disease is self-limited, and the mature worms gradually die and disappear.

Although a few hookworms in an individual may not do him serious harm, he is a reservoir of infection and is liable, through his stools, to transmit a severe infection to others. All cases in whose feces hookworm eggs are found should be treated, as even a slight infection impairs efficiency.

PREVENTION AND ERADICATION OF HOOKWORM

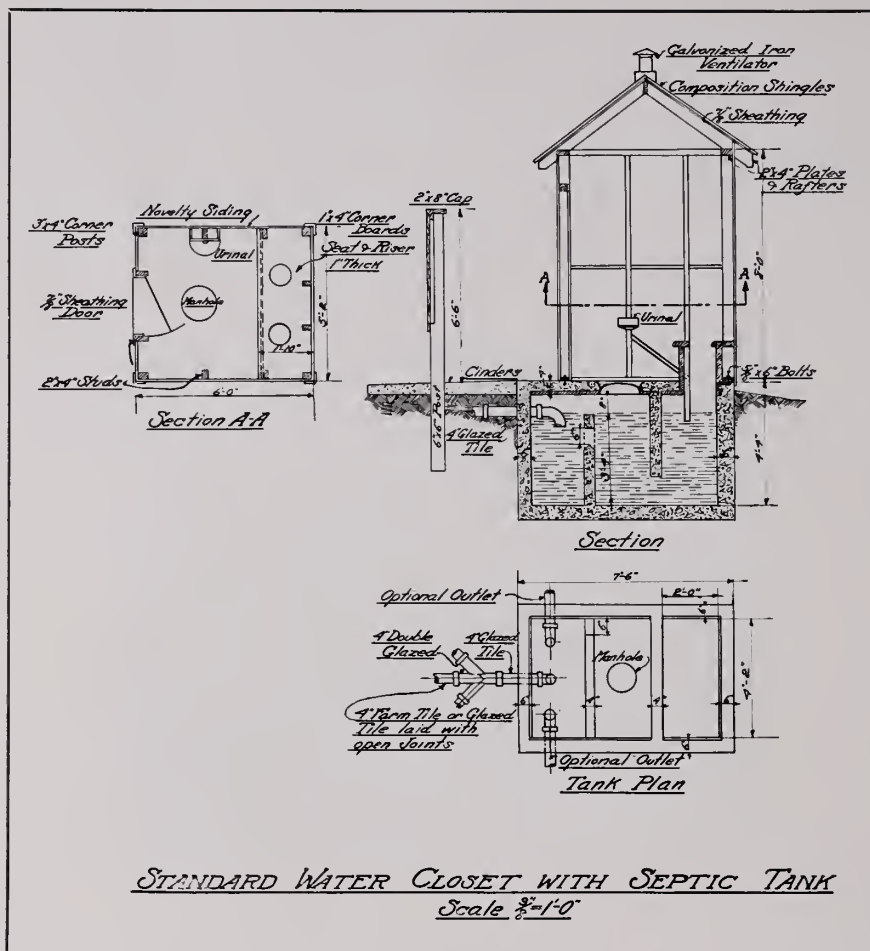
The cause of the disease, the method of infection, and the cure are known. It should not be difficult, therefore, to prevent infection and gradually eradicate the disease. This, however, depends upon a number of factors which are difficult to control, particularly in tropical countries. In many of the districts where Hookworm disease is prevalent the victims are ignorant, careless, filthy in their habits, and indifferent to sanitary methods. In consequence, it is very difficult to secure intelligent coöperation.



Insanitary condition well adapted for breeding Hookworms and infesting human beings.

To prevent infection, fecal matter must be properly disposed of or destroyed. This can be done by the use of sanitary privies, septic tanks, or by incineration. If these conveniences are not at hand, the feces should be deeply buried under two feet of soil. All these methods destroy the eggs and larvæ of hookworms. Localities where exposed feces have been deposited in secluded or shady places are to be avoided unless boots are worn and other measures taken to protect the skin from possible infection. Under favorable conditions larvæ in the infectious stage may live from three to five months after the feces have been deposited. Cane and banana cultivations and other tropical vegetation possess the necessary humidity, shade and temperature to favor the development of hookworm larvæ, and maintain them in the infectious stage.

It is very important, therefore, that laborers in tropical countries be provided with proper latrines or privies and taught to use them. If these measures were universally enforced in infected districts and all cases suffering from the disease were thoroughly treated, we could soon look forward to the hope of its eradication. The beneficial results of treatment have been demonstrated in a great many countries. Governments and commercial organizations have been impressed with these results, and



have made provision for the intelligent treatment of Hookworm disease in all communities where it is known to exist. We need, however, more than this. The people must be educated to realize the serious results which follow hookworm infection, the necessity of seeking the means of cure, and the importance of taking care of their fecal discharges so as to prevent the spread of the disease.

THE CURE

Three drugs are now used to cure the disease, namely, Thymol, Oil of Chenopodium, and Carbon Tetrachloride.

Thymol is administered in the following dosage according to age:

Under 5 years old	7 1/2 grains
From 5 to 9 years old	15 grains
From 10 to 14 years old	30 grains
From 15 to 19 years old	45 grains
From 20 to 59 years old	60 grains
Above 60 years old	30 to 45 grains

The dose is thoroughly powdered with equal parts of milk sugar. It is then divided into two parts and placed in capsules or cachets. At bedtime on the evening preceding the treatment, from one to two ounces of a 50 per cent solution of Epsom salts is administered. The next morning no breakfast is allowed the patient. At 7 A. M. one-half the dose of thymol is given and the other half at 9 A. M. At 11 A. M. the dose of Epsom salts is repeated. No alcoholic or fatty preparations should be taken preceding, during or immediately after the treatment, as thymol is soluble in these substances and is liable to absorption, with poisonous symptoms supervening. The treatment can be repeated in from five to seven days. Some prefer to divide the dose of thymol into three parts and give them at hourly intervals.

Oil of *Chenopodium*. Dr. S. T. Darling's method of administration is as follows: A preliminary saline purge of 1 ounce magnesium sulphate in 10 ounces of water is given after the evening meal the day before treatment. The following morning at 7 A. M. 24 drops of oil of chenopodium, freshly placed in empty hard gelatin capsules (ready prepared soft capsules have been found relatively insoluble and inefficient), are given on a fasting stomach; and at 9 A. M. a final saline purge is given with a full glass of water. After the patient's bowels have acted well, he may breakfast. Special attention should be paid to insuring free purgation after the post-vermicide purge has been given, for the chenopodium should not be permitted to remain in the host after its vermicide purpose has been accomplished. The treatment should be repeated after an interval of about two weeks. One treatment should never follow immediately upon another, for the toxic effects of the drug are cumulative, and serious poisoning may result.

In the field, to economize the time of the nurse or orderly and thus reduce expenses, the preliminary purge at night may be eliminated, but in this case the dose of chenopodium must be divided. A light supper is permitted the evening before treatment, and at 7 A. M. the next morning, on a fasting stomach, 12 drops are given in hard gelatin capsules; at 9 A. M. 12 drops (*i. e.*, the other half of the dose) follow. At 10.30 A. M. a saline purge (magnesium sulphate) is given with a glass of water. Breakfast is permitted after the bowels have acted well. Treatment should be repeated, but never until after a period of ten to fourteen days has elapsed.

Twenty-four drops of chenopodium given in two divided doses two hours apart very rarely produce severe toxic symptoms in adults. Discomfort, though frequently observed, usually disappears soon after the final purge. There seems to be nothing gained by giving the preliminary purge when the dose is divided. By either method—with or without the preliminary purge—the drug remains in contact with the worms sufficiently long and in sufficient concentration. However, if even a small amount of food is taken when the drug is given in divided doses, the percentage of worms removed is greatly diminished.

Inasmuch as children appear to be peculiarly susceptible to the effects of chenopodium, in treating them it is advisable to exercise extreme care

that too large a dose may not be given. The dose should be smaller than that calculated by Young's rule. The following table indicates the dosages which experience has indicated are safest for the treatment of children:

Age	Dose in Drops
4.....	3
6.....	4½
8.....	6
10.....	9
12.....	10
13-14.....	12
15-16.....	15
17-18.....	20
19-20.....	24

Carbon tetrachloride has recently come into extensive use, and has proved very efficacious. The usual method of administration for an adult is to give from 45 to 60 drops in water at 8 A. M. and follow it at 11 A. M. with from one to two ounces of a 50 per cent solution of magnesium sulphate. With this drug great care must be used to obtain a pure preparation. Unfortunately, fatal results have occasionally followed its use by causing necrosis of the liver. With younger people the dose should be reduced according to age. Treatment with this drug should not be repeated in less time than from two to three weeks.

The dosages above mentioned for all three drugs are for the average individual at the age mentioned, but weight and physical conditions should always be taken into consideration and the dosage modified accordingly. Of the three drugs, it should be mentioned that oil of chenopodium is peculiarly effective against round worms (*Ascarides*) as well as hookworms. Round worms are very common infestations in the American tropics, which makes the chenopodium treatment particularly desirable.

In conclusion, in order to eradicate hookworm the inhabitants of infected districts must be thoroughly informed concerning:

(First) The chief symptoms and serious results of Hookworm disease as well as the likelihood of having the disease without knowing it.

(Second) The necessity of thorough treatment and its beneficial results.

(Third) The nature of the infection, its occurrence in the fecal discharges, the conditions favorable for its development, and the mode of infection.

(Fourth) The necessity of protecting themselves and others by exercising care with the fecal discharges. They should be passed in properly constructed latrines or privies, and if this is not practical, they should be buried deeply.

NOTE: We are indebted to the International Health Board for the illustrations which accompany this article.

